

ANSWERS to Crystal Ball questions on Explaining Entropy change

1) Reaction A has the same number of moles of reactants as products, the states of matter also remain the same so there is no change in entropy.

The entropy change does increase for reaction B because the state changes from a solid to a gas and there is an increase in the number of moles from 1 mole of reactant to 2 moles of products.

In reaction C there is a decrease in entropy because there are 4 moles of gases as reactants and only 2 moles of gas as products.

Reaction D has no change in entropy because there are 2 moles of gases on both the reactant and products side.

Reaction E also has an increase in entropy because there is only 1 mole of gas on the reactant side but 2 moles of gas on the product side of the equation, so the number of moles of gases has increased.

The reaction with the largest entropy increase is reaction B because not only the number of moles has increased but also the change in state. The particles in the gaseous carbon dioxide have considerably more energy and random movement so the disorder is greater than that of the solid state as a reactant.

2) Entropy is a measure of the level of disorder in a system. The particles in a gas are more disordered than the particles in a solid of the same substance.

Particles in a gas have a lot of energy, move quickly and randomly, they collided frequently with each other, the particles are not arranged in an ordered manner in a lattice arrangement.

Particles in a solid are arranged in neat ordered rows, in a regular lattice arrangement, the particles vibrate slightly and have very little energy.

By discussing the particle arrangement of both a gas and solid of the same substance, it is very clear to visualise that the particles in a gaseous state have much greater entropy than those in a solid state.

3) $\text{NH}_4\text{Cl(s)} \rightarrow \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$

The entropy will increase as the ammonium chloride dissolves because there is a change of state from solid to aqueous (with an associated increase in disorder) and two particles are replacing one.

4) **extension:** Spontaneity of a reaction depends on both the change in enthalpy and the change in entropy of the system. A reaction with a negative value of ΔH is an exothermic reaction so releases energy to the surroundings, exothermic reactions are usually spontaneous.

But reaction with a negative value of ΔS is becoming more ordered, so the temperature must be decreasing for the level of disorder to be decreasing.

Thus the spontaneity of the reaction can only be predicted by considering both the enthalpy and the entropy of the system. Mathematically the relationship between the enthalpy and entropy is $\Delta G = \Delta H - T\Delta S$ where ΔG is known as the Gibbs Free Energy. For a reaction to be spontaneous, ΔG must have a negative value. So, if the ΔS is negative and ΔH is also negative, as long as the reaction is carried out at a low temperatures, $T\Delta S$ will still be less than ΔH , so ΔG will be negative and the reaction will be spontaneous. At higher temperatures the value for $T\Delta S$ will be greater than ΔH so then the value of ΔG will become positive and therefore a non-spontaneous reaction.